Coal in Nova Scotia

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"the Coals are within three feet of surface, and the most excellent ever seen. There will be no occasion for digging underground, or making drains to carry off the water, as in England, for the mines consist of entire mountains of coal, and are sufficient to supply all the British plantations in North America for ten centuries."

Extracted from a letter from Halifax, Scots Magazine, April 1765.

Preface

During the 265 years since coal was first mined on the Island of Cape Breton in 1720, the coal industry has led all others in forging the economic framework of Nova Scotia. Coal mining historically has taken place in several coal districts in Nova Scotia. The four major areas are the Cumberland coal basin (Joggins-Chignecto, and Springhill coalfields), the Pictou coalfield, the western Cape Breton coalfields (St. Rose-Chimney Corner, Mabou, and Inverness) and the Sydney coalfield.

During the late 1950s, coal mining in the Province declined sharply due to increased pressures in the marketplace created by an abundance of inexpensive imported oil and the high costs of transporting coal to the central Canadian market.

The formation in 1966 of a federal Crown agency, the Cape Breton Development Corporation (CBDC; informally known as Devco), led to the amalgamation of several private operations and a revitalization of mining in the Sydney coalfield. With the upheaval in the world energy situation during the late 1970s, interest in the Province's coal resources was rejuvenated.

The Cape Breton Development Corporation, with the aid of the Nova Scotia Department of Mines and Energy, has begun work on the expansion of underground mining in the Sydney Coalfield. Coal-waste reclamation projects have been initiated by the private sector, and exploration by private companies of other coalfields within the Province is currently underway. The development and promotion of our coal resources is the goal of the Coal Section of the Nova Scotia Department of Mines and Energy.

Aside from the importance of developing an indigenous energy supply, the significance of coal mining from an economic standpoint is great. In 1983, coal mining accounted for 59 percent of mineral and petroleum production in the Province with a value of $146,700,000. In 1983, the number of persons directly employed in the Province's coal-mining industry was 4,636, which represents over 70 percent of employees in all metallic and industrial mineral operations in Nova Scotia.

The long history of coal mining and associated geological research has created a wealth of information related to our coal resources. The aim of the publication, prepared by the Coal Section of the Nova Scotia Department of Mines and Energy, is to present a summary of various aspects of coal in Nova Scotia, including its origin, the geological backgrounds of the various coalfields; coal-exploration techniques; the history, methods and future of coal mining; and new developments in coal-utilization research. The challenge of presenting such a broad spectrum of information to an equally broad and diverse audience is formidable. In recognition of this fact, a glossary of terms and a selected bibliography of further and more detailed reading have been included.

It is hoped that this publication will introduce the reader to the scope and significance of the study and development of this important and valuable indigenous energy resource, the role that coal has played in our past and the role that it will play in the future of Nova Scotia.

Many persons contributed to the creation of this publication. The text was written by various members of the Coal Section of the Department of Mines and Energy. The senior author was John H. Calder, the other authors being C. E. Bain, S. Chesal, K. S. Gillis, D. M. MacNeil, R. D. Naylor and W. J. Palmer. Appreciation is gratefully extended to the many individuals involved in the preparation, graphic design, editing and production of the test and illustrations.

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1. The Origin of Coal

Coal (Old English and Middle England *col*): a compact, stratified combustible rock composed largely of chemically and physically altered plant remains mixed with a variable amount of inorganic material

Coal is the result of a process that begins with the formation of *peat.* Peat is formed by an accumulation of plant material in swamps with a high water table and poor drainage. In this environment, stagnating groundwater covers the dead plant debris, preventing significant decomposition. As the peat accumulates, it becomes compacted, largely due to loss of water. Between seven and twenty-seven metres of peat are required to form a one-metre layer of *bituminous coal* which may represent the accumulation of plant debris over 6,000-9,000 years.

The major coal seams of Nova Scotia were formed in the Late Carboniferous period approximately 300 million years ago. The flora then were predominantly primitive *spore* -bearing plants although some early seed-producing plants also existed. Figure 1 is a reconstruction of a Carboniferous coal swamp. Similar conditions existed in a variety of environments in Nova Scotia including shallow lakes, *floodplains* by *meandering rivers, braided rivers* and *river deltas,* and nearby upland areas.

The plant types which flourished and accumulated to form peat in these locations varied according to their environment. Factors within the swamp such as oxygen supply and bacterial activity affected the peat Inorganic sediments (clay, silt and sand) were carried by streams and by wind into the peat swamps, particularly near their margins. These and other factors determined the nature of the coal seams mined today in Nova Scotia, especially their *ash* (inorganic matter) and *sulphur content* (Figures 2 and 3).

Figure: (Not presently available)
Figure 1. *Reconstruction of a Late Carboniferous coal swamp. By permission of the Field Museum of Natural History, Chicago.*

Figure: (Not presently available)
Figure 2. *A typical Nova Scotian bituminous coal seam; the Rodney seam, Springhill coalfield. NSDME.*

Figure: (Not presently available)
Figure 3. *Microscopic view of coal (Rodney seam, Springhill), showing macerals of various shape and relative brightness (reflectance). Contorted band in center (semifusinite) represents crushed plant cell walls. Bright spheres are framboids of pyrite (FeS_2). NSDME.*

Peat formation was usually halted by an environmental change such as a sudden shift (avulsion) in the position of a river or an increased rate of basin *subsidence.* If the peat was not eroded but buried under sediments such as mud and sand, it would be preserved to undergo the process of *coalification.* In many cases, plants which flourished in the peat swamp when it was buried by inorganic sediments have been preserved as delicate fossils in overlying (roof) *mudstones* and *shales* (Figure 4) or an upright trees (Figure 5) in mudstones and *sandstones.*

Figure: (Not presently available)
Figure 4. *Fossil fern (Alethopteris sp.) in mudstone, from root of Rodney seam, Springhill coalfield. NSDME.*

Figure: (Not presently available)
Figure 5. *Cast of an erect tree trunk (Sigillaria sp.) emanating from a coal seam. Sydney coalfield. Courtesy of Douglas MacDonald.*

Through time, with the increasing pressure of overlying sediments, the peat was transformed to coal through the process of coalification. This process is a gradual change from peat through *lignite* (brown coal), sub-bituminous coal, bituminous (black) coal, semi- *anthracite* and classification of coal is presented in Table 1. Nova Scotia coals are predominantly bituminous, although there is significant from coalified to coalfield.

Table 1. Summarized ASTM Classification of Coal by Rank.

				Calorific Value[2]	
Volatile Matter %[1]	**Fixed Carbon %[1]**	**Class**	**Group**	**BTU/lb**	**MJ/kg**
2	98	Anthracitic Coal	Meta-Anthracite		
8	92		Anthracite		
14	86		Semianthracite		
22	78	Bituminous Coal	Low Volatile Bituminous		
31	69		Medium Volatile Bituminous		
			High Volatile A Bituminous	14 000	32.6
			High Volatile B Bituminous	13 000	30.2
			High Volatile C Bituminous	11 500	26.7
		Sub-bituminous Coal	Sub-bituminous A	10 500	24.4
			Sub-bituminous B	9 500	22.1
			Sub-bituminous C	8 300	19.3
		Lignitic Coal	Lignite A	6 300	14.7
			Lignite B		

[1]Dry, mineral-matter-free basis
[2]Moist, mineral-matter-free basis

Fossil Carboniferous plants can be found at various localities in Nova Scotia. The coastal exposures of Cape Breton

County from Point Aconi to the Donkin-Morien area, and the cliff exposures of the western Cape Breton coalfields such as Mabou provide sites for the fossil collector. Strata immediately overlying the coal seams are typically most abundant in ancient plants. In Cumberland County, the Joggins fossil cliffs have long provided geologists and collectors a source for fossil plants. Occasionally stands of upright *Calamites sp.* or individual trees such as *Sigillaria sp.* and *Lepidodendron sp.* can be seen in the cliffs. The roots of the latter two trees, known as *Stigmaria sp.* are often found subparallel to bedding, usually immediately beneath a coal seam. Other localities that have traditionally been visited by fossil plant collectors are the mine dumps of the various coal mines of Nova Scotia.

Photo: (Not presently available)
Miners

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2. Coalfields and Coal Districts of Nova Scotia

The coal *resources* of Nova Scotia are estimated to be three billion tonnes. These coal deposits are spread over several coalfields and (smaller) coal districts, although the Sydney coalfield of Cape Breton Island contains the major portion. It is probable that undiscovered resources exist in some areas of the Province's *coal measures*. Figure 6 illustrates the distribution of known coal resources within the Province.

Coal quality varies significantly from coalfield to coalfield and, in some cases, even more so from seam to seam within a coalfield. The majority of coals are high *volatile* bituminous A, although high volatile bituminous B and medium-to-low volatile coals are present as well.

The majority of the Coal Section's efforts over the past few years has been in applied research and delineation of coal resources in various coalfields within the Province.

Figure: (Not presently available)
Figure 6. *Relative distribution of coal resources by coalfield in Nova Scotia.*

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Geological Background

The coals of eastern Canada were formed within the broad Fundy Basin of deposition (Poole 1967). This basin developed after the Acadian orogeny (mountain-building event), during the late Devonian period approximately 400 million years ago. The locus of major deposition was in the area of the Magdalen Islands (Bradley 1981). During the development of this large basin in the Carboniferous period, sedimentation was at times localized in depositional sub-basins (e.g. the Cumberland, Pictou, and Sydney basins), some of which contain sites where repeated episodes of coal accumulation occurred. These sites comprise the various coalfields of Nova Scotia.

The oldest coals of Nova Scotia are found as minor occurrences in the Devonian and Lower Carboniferous Horton Group. This early period of coal deposition was interrupted by widespread marine conditions, as represented by the deposition of Windsor Group *evaporates*. Major coal deposition did not occur until the terrestrial Late Carboniferous Riversdale Group was deposited over much of northern Nova Scotia and Cape Breton Island (Figures 7 and 8). The oldest productive coal districts in the Province belong to the Riversdale Group; the St. Rose-Chimney Corner and Port Hood coalfields, of Westphalian A age, on the west coast of Cape Breton Island.

Figure: (Not presently available)
Figure 7. *Coalfields and districts of Nova Scotia, showing distribution of coal-bearing Riversdale, Cumberland, and Pictou groups.*

Figure: (Not presently available)
Figure 8. *Geological groups of the Carboniferous period in Nova Scotia.*

More extensive coalfields were subsequently deposited in the Cumberland Group. These sediments are essentially restricted to the Cumberland Basin in the northwest mainland of the Province, where the Westphalian B Joggins-Chignecto and Springhill coalfields are situated. Other, less extensive, coal districts exist at Salt Springs and near Oxford.

The Pictou Group (and equivalent Stellarton and Morien Groups) of Westphalian C to D age was deposited over much of the northern mainland and Cape Breton Island. The most extensive and youngest coal deposits of Nova Scotia occur within this group, including the Sydney, Inverness, and Mabou coalfields and the Glengarry district of Cape Breton Island, and the Pictou and Debert-Kemptown coalfields of the northern mainland.

Photo: (Not presently available)
Miner

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Coalfields of the Riverdale Group

Port Hood Coalfield

The Port Hood coalfield lies on the west coast of Cape Breton Island, on the gently dipping east limb of a *synclines* which plunges to the southwest. The six-hundred-metre-thick coal-bearing section dips beneath the Gulf of St. Lawrence. Though only one mineable seam has been identified (Figure 9), the coalfield (Figure 10) is open-ended to the south and the possibility exists that coal seams may persist offshore beneath the southern tip of Henry Island. Gersib and McCabe (1981) describe the environment of deposition as a continental floodplain with *fluvial* and *fluvio-lacustrine* deposition.

The coals of Port Hood have a rank of high volatile B to C bituminous. Mining in this field was abandoned in 1969 primarily due to economic considerations.

Figure: (Not presently available)
Figure 9. *Major coal seams of the Port Hood coalfield.*

Figure: (Not presently available)
Figure 10. *Coalfields of western Cape Breton Island.*

St. Rose-Chimney Corner Coalfield

The St. Rose-Chimney Corner coalfield also occurs on the west coast of Cape Breton (Figure 10). Separated from the

Chimney Corner field to the north by a 3.2 km-wide zone of block faulting, the St. Rose field is of limited area due to a *fault* downdip of the mine workings which brings it into contact with evaporites of the Windsor Group.

The coal-bearing section is 150 m thick at Chimney Corner, increasing to 250 m at St. Rose. At Chimney Corner, the coal seams dip beneath the Gulf of St. Lawrence. Hacquebard (1951) has correlated the seams of the Chimney Corner and St. Rose fields (Figure 11) on the basis of microscopic coal *petrography*. Bivalve (shell) fossils overlying the coals suggest a *lacustrine* environment.

The rank of coals in both areas is high volatile C bituminous. A small underground mine (of the Evans Coal Company) has been in continuous operation at St. Rose since the late 1940s.

Figure: (Not presently available)
Figure 11. *Stratigraphic columns of the Chimney Corner and St. Rose coalfields showing correlated coal seams.*

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Coalfields of the Cumberland Group

Joggins-Chignecto Coalfield

The Joggins-Chignecto coalfield stretches over 30 km from the shores of the Cumberland Basin. Bay of Fundy, in the west through River Hebert, Maccan, Chignecto, and Fenwick to Styles Brook in the east (Figure 12). The seams dip to the south, on the south flank of the Windsor evaporite-cored Minudie *anticline*. This structure also forms the north limb of the Cumberland coal basin. At Joggins, the coal section (lower fine *facies* of the Cumberland Group) is approximately 1500 m thick, thinning dramatically eastward.

Figure: (Not presently available)
Figure 12. *Coalfields of the Cumberland basin, Cumberland County, Nova Scotia.*

The depositional environment of the Joggins-Chignecto coalfield is one which has spawned some debate among geologists. *Paleoenvironments* suggested include *deltaic* (Duff and Walton, 1972), meandering fluvial (Kaplan and Donahue, 1980) and *anastomosed* fluvial deposition (Rust and Gibling, 1983). Studies by the Coal Section in related coalfields of the Cumberland Basin indicate that the depositional environment is part of a complex of gradational facies changes within the basin from alluvial fans in the south to lacustrine in the north. Fluvial deposition with coals formed in a shoreline position is suggested. The coals exhibit similar depositional styles to those of the Salt Springs and Roslin area (Calder, 1982).

The coals at Joggins (Figure 13) are characteristically thin, commonly less than one meter; however, the coalfield has witnessed extensive mining in the past. The last mining operation closed in 1979, and most readily accessible coal resources have been exhausted. The coals of the Joggins-Chignecto coalfield have a rank of high volatile B bituminous.

Figure: (Not presently available)
Figure 13. *Major coal seams in the Joggins-River Hebert district of the Joggins-Chignecto coalfield.*

Springhill Coalfield

The Springhill coalfield occurs on the south limb of the Cumberland coal basin (Figure 12). The coalfield has been moderately to severely deformed by Windsor Group evaporites of the Black River *diaper*. The structural configuration of the Springhill coalfield is that of a southwesterly plunging anticline, the axis of which is severely faulted. The coal measures attain a maximum thickness of 1,080 m on the north limb of the anticline. Tentative correlation with a coal-bearing section intersected by drillholes (the Cera Caledonia 74-2 and 74-3, and Pettigrew boreholes) approximately 20 km southeast of Springhill indicates thinning to 150 m in a position more proximal to the pre-Carboniferous Cobequid highlands. This upland was the source of much of the sediment that filled the basin. The major coal seams of Springhill are depicted in a composite *stratigraphic* column in Figure 14.

Figure: (Not presently available)
Figure 14. *Idealized stratigraphic column of the Springhill coalfield showing major coal seams.*

Within the coalfield, seams exhibit *progressive onlap* over *braidplain* and *distal alluvial-fan* sediments derived from the Cobequids to the south. The center of coal deposition within successively younger seams migrates to the south. Elongate coal swamps formed adjacent alluvial fans to the south, and appear to have been controlled to the north by major-trunk meandering rivers (Calder, 1984). Minor *ephemeral streams* occasionally invaded the coal-forming moor where it bordered the alluvial fans. Early basin filling may have been characterized by transverse flow terminating in a shoreline of possibly lacustrine origin.

The coals of the Springhill coalfield exhibit an increase in rank with depth from high volatile to medium volatile A bituminous. The bulk of remaining resources occur on the north limb of the anticline downdip from old workings. Below a vertical cover of 450-600 m, the workings are prone to rock bursts or "bumps", a phenomenon instrumental in the closure of the major collieries in the late 1950s. Notley (1980) has suggested that variations in mining methods could partially alleviate this significant problem. Resources of lesser quality exist within the axial region of the anticline in a structurally complex geological setting. In 1983, Novaco Limited completed an open-pit operation in this area, which may be amendable to underground development.

Photo: (Not presently available)
Miner

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Coalfields of the Pictou Group

Debert-Kemptown Coalfield

The Debert-Kemptown coalfield (Figure 7) is situated within a narrow, structurally complex, fault-bounded syncline. The extent of the coalfield has never been defined accurately. Within this syncline, the Pictou Group occupies an area of approximately 100 km. Although the depositional environment is largely undocumented, it is probably fluvial. The coals of the Debert-Kemptown field have a rank of high volatile B bituminous. The only coal operations in the district were the short-lived mines that operated between 1903 and 1936.

Pictou Coalfield

The Pictou coalfield is situated in the north-central part of Pictou County. The basin is 18 km wide (east and west) by 9 km long (north and south) and encompasses an area of approximately 165 km^2 (Figure 15).

Figure: (not presently available)
Figure 15. *Geological map of the Pictou coalfield.*

Mining has taken place in this field over the past 160 years, and relative to its size, it has been one of the most extensively exploited coalfields in Canada. Approximately 55 million tonnes of coal have been mined in this field. At present, no large-scale mining is carried out.

The Pictou coalfield lies within a *graven*. The coal basin was slowly filled with a succession of sediments, beginning with the New Glasgow *conglomerate*, derived from highland areas to the southwest of the basin. Infilling of the basin continued until drainage was impeded, shallow lakes developed and the fluvio-lacustrine deposits of the Stellarton Group were laid down. Within the Stellarton Group, the coal deposits of the three mining districts (Westville, Stellarton, and Thorburn) of the basin are found. Deposition of the coal measures commenced in the Westville district with subsequent deposition occurring in the Stellarton and Thorburn districts: the center of the deposition moved progressively west to east so that the oldest coal seams are found in the Westville district and the youngest coal seams in the Thorburn district.

As a result of their fluvio-lacustrine (Hacquebard and Donaldson 1969) depositional milieu, the seams tend to be characterized by low-ash coal in the center of the basin, grading laterally to high-ash coal, thence to shaly coal and finally coaly shale on the periphery of the basin. This phenomenon has been described as "lithification" (Hacquebard and Donaldson, 1969).

The coals of the Pictou coalfield are of thermal quality and are classed as high volatile A bituminous coals. The notable exception is the Acadia seam in Westville, the only known low volatile coal in eastern Canada. Petrographic studies have indicated that it is suitable for use as a blend with *metallurgical-quality* coal. There are fifteen major coal seams (Figure 16) in the basin ranging from 1-14 m in thickness; twelve have been mined in the past. Much of the better quality coal has been mined the remaining resources lie in peripheral areas where quality deteriorates. Exceptions are the Acadia and Scott seams in Westville where remaining resources lie *downdip* of old workings, at a depth of 600-1200 m. Significant near-surface and deeper resources exist in the Stellarton district and in the Westville district within the Foord, Acadia, and Scott seams. In the Thorburn district, approximately one million tonnes may be amenable to surface mining.

Figure: (not presently available)
Figure 16. *Idealized stratigraphic column of the Pictou coalfield showing major coal seams.*

Mabou-Inverness Coalfield

Though the Mabou and Inverness coal district occupy separate land areas approximately 10 km apart (Figure 10), they are thought to be part of the same overall sequence and to merge at depth beneath the Gulf of St. Lawrence (Hacquebard 1975). At Mabou, less than one square kilometre of coastline is underlain by the coalfield, which dips under the sea to the west. The exposed area is severely faulted, but there is a stratigraphic section of about 365 m along the shore in which six seams have been identified. Norman (1935) suggested that deposition took place on the *subaerial* portion of a delta.

Faulting obscures the relationship between the Mabou coalfield and the Inverness coalfield to the north; however, fossil spores, offshore drilling, and *seismic surveys* indicate that the seams at Inverness are stratigraphically higher (i.e., younger) than the Mabou section (Figure 17). Ten seams outcrop at Inverness again in a section which dips moderately seaward. Five seams have been mined; however, faulting offshore has limited their submarine extent. It is interesting to note, however, that a petroleum exploration well some 50 km offshore at Brion Island penetrated a six-hundred-metre-thick coal-bearing section in the Pictou Group that may correlate with the Mabou-Inverness section

(Hacquebard 1975).

The coals are high volatile bituminous C. Limited mining went on at Mabou from 1899 to 1909. At Inverness, coal was first produced in 1865 but has not been mined since the mid-1960s.

Figure: (not presently available)
Figure 17. *Stratigraphic columns of the Mabou and Inverness districts of the Mabou-Inverness coalfield (the major seams of the Inverness section overlie those of Mabou).*

Sydney Coalfield

The Sydney coalfield (Figure 18) contains the largest coal *reserve* in eastern Canada. The approximately two-thousand-metre-thick coal-bearing Morien Group underlies a roughly triangular area with an apex south of Sydney and a base off the south coast of Newfoundland. More than 98 percent of the coalfield is submarine although eleven of the thirteen known major coal seams (Figure 19) outcrop on land. Their geological settings are reasonably well known through surface exposure and underground workings. The only direct information available on their offshore geology comes from deep coal mines and the twenty wells drilled for petroleum and coal, and this data is largely limited to the area within 10 km of the Cape Breton coast. Geophysical techniques, primarily seismic surveying, have been used to define the geological structure of the greater part of the submarine basin.

Figure: (Not presently available)
Figure 18. *Geological map of the Sydney coalfield.*

Figure: (Not presently available)
Figure 19. *Idealized stratigraphic column of the Sydney coalfield showing major coal seams.*

The depositional environment is largely fluvial. The river systems had their headwaters in a mountainous upland whose present-day eroded remnants are represented by the crystalline rocks of the Forchu-East Bay structural blocks and the Cape Breton Highlands. Great volumes of coarse sandy sediments accumulated in a braided river environment leaving 900 m or more of sediments in the eastern part of the basin where deposition was initiated and subsidence was greatest. The braidplain migrated steadily westward. As the stream gradients decreased, the rivers, now flowing over an extensive, possibly coastal, floodplain, took on the character of meandering streams with fewer major channels. These river channels were separated by broad marshy flats which became the locus for deposition of muds (*overbank deposits*) when the rivers flooded.

Early *clastic* deposition and a later initiation of major peat deposition occurred in the southeastern part of the basin. Significant peat accumulation began with the formation of the Tracy seam, the lowest mineable seam in the section. The progressive westward onlap of younger seams reflects the overall development of the Morien Group. The later seams (Harbour, Hub, and Point Aconi) are well developed over most of the basin. Throughout Morien time the centre of deposition remained in the easterly Donkin area where the seams attained their greatest thickness. The seams invariably deteriorated near the western basin margin where they split due to an influx of sediments from the highlands.

The major structural features of the Sydney coalfield are the bounding faults (the Mountain fault on the west and the Mira River-Bateston fault on the southeast) and the large-scale *folds* which define a broad structure known as the Sydney *synclinorium*. These northeast-trending folds closely reflect the underlying basement structure and probably represent draping and differential compaction of the sediments over the uplifted basement blocks (e.g. Coxheath

Hills, Boisdale Hills).

The coal seams dip gently approximately 5° toward the deeper offshore basin centre except where affected by the northeast-trending open *flexures*. Even on the flanks of these folds, dips rarely exceed 15°. The fact that seams tend to be somewhat thicker in the synclines than over the anticlines suggests that these structures are at least in part contemporaneous with deposition of coal.

The rank of the Sydney coals varies considerably, increasing to the east and with depth. They are classified generally as high volatile A bituminous (Hacquebard 1983) but in places reach medium volatile bituminous.

All underground mining operations in the Sydney coalfield are managed by the Cape Breton Development Corporation; two surface operations and two coal-waste reclamation operations are conducted by other groups. At Point Aconi, Novaco Limited is the final stages of an open-pit operation on the Sydney Main Harbour seam, while T. Brogan and Sons operates an open-pit mine on the Bonar (Lloyd Cove) seam. Selminco Inc. conducts two coal waste-bank reclamation projects in the coalfield.

Photo: (Not presently available)
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3. Exploration Techniques

Coal seams are organic sedimentary *strata* or beds which lie essentially parallel to enclosing inorganic sediments such as mudstones and sandstones, much like a page in a book. Exploration techniques aimed at locating and assessing coal seams are used with this phenomenon in mind. The major exploration tools geologists use when searching for coal fall within three broad categories:

a. geological mapping,
b. *diamond drilling* and
c. geophysical methods that may include the logging of diamond-drill holes and seismic surveys.

There is more to coal exploration than locating where a coal seam lies below the ground or where it may outcrop at the surface. It is also important to reconstruct the paleoenvironment of the coalfield and to gain an understanding of the coal basin's configuration. This enables the geologist to predict trends in the seam's thickness and qualitative parameters such as the sulphur and ash content likely to be found in various areas of the coalfield. One can gain insight into the nature of the coalfield by mapping coal seams and associated strata where they may be exposed through erosion, such as along streams and coastlines (Figure 20). Structure and depositional trends can be partially reconstructed by this method of exploration.

Figure: (not presently available)
Figure 20. *Geologists mapping outcrop of rocks of the Cumberland Group, Salt Springs coal district. NSDME.*

Subsequent investigation often is done by diamond drilling (Figure 21). This method is utilized extensively by the Coal Section in its exploration and development efforts. The rock core obtained through drilling is stored systematically in core boxes where it is described or "logged" by a geologist. Thus, a complete stratigraphic record of the underlying sedimentary rocks may be derived and coal samples may be obtained for analytical purposes.

Figure: (not presently available)
Figure 21. *Diamond drill used in coal exploration. NSDME.*

To enhance the data gained through diamond drilling, geophysical logging of the drillhole is conducted by an independent contractor specializing in this field. This operation (referred to as "geophysical," "slimline." or "downhole" logging) invariably utilizes a probe, or "sonde." lowered into the drillhole on an electronic cable, usually from a truck-mounted housing containing a sophisticated analyzing and recording system (Figure 22). The geophysical logs run may include natural gamma, gamma-gamma (density), neutron-neutron, resistivity, sonic, or caliper logs - the natural gamma and density logs are the two most often used. The natural gamma is particularly useful for indicating *lithological* changes and is therefore an important tool in the correlation of strata between drillholes. The natural gamma log will not, by itself, unequivocally identify coal seams; therefore, the density is commonly run in conjunction with it. Coal seams are characteristically of low density (1.3-1.5 g/cm^3) in comparison with associated strata such as mudstone (e.g., 2.7 g/cm^3). The density log of a coal intersection is particularly useful because it can indicate very slight changes in inorganic (ash) content.

Figure: (not presently available)
Figure 22. *A trailer-housed module from which the drillhole is geophysically logged upon completion of drilling. NSDME.*

The Coal Section uses these logs and detailed visual logging of coal intersections to produce a "seam profile." By correlating the geological logs, areas where core was lost during drilling are deduced, and the coal core is sampled accordingly. The seam profile indicates graphically the megascopic (visual) nature of the coal, areas of lost core, and corresponding proximate analyses of the coal core (Figure 23).

Figure: (not presently available)
Figure 23. *A "seam profile" graphically depicting the correlation of the geophysical logs of the coal seam, with corresponding* proximate *analyses of the coal.*

Seismic surveys are generally used less extensively than the above methods of exploration. They are usually conducted in areas where information regarding the general structural and stratigraphic nature of a coal basin, or parts thereof, is required. Such areas are often deemed too complex or too vast to be outlined solely through diamond drilling; however, it is normal practice to augment seismic surveys with drilling programs. Areas of western Cape Breton and the Sydney coalfield that posses submarine coal resources are examples of areas where seismic (in the case, marine) surveys can provide valuable insight into the geology of coal basins.

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4. A History of Coal Mining in Nova Scotia

"In the bottom of a small brook, running through a wild forest of beech and maple, a poor farmer has been digging coal, one of the greatest treasures of the earth."

The first account of coal at Springhill by Abraham Gesner in 1836

The mining of coal has been a major factor in the industrial and social development of the Province of Nova Scotia.

Nicholas Denys, governor of Nova Scotia, stated in dispatches to France in 1673 that there was "a mountain of very good coal four leagues up Spanish River," near Cow Bay, Cape Breton Island. By 1720, a mining operation had been initiated to supply the French fortress Louisbourg and soon after, French Acadians began extracting coal from the famous fossil cliffs at Joggins in Cumberland County. The first officially recorded export of minerals from Canada occurred in 1724 when a shipment of coal was exported from Cape Breton to Boston. In Pictou County, coal was discovered on the East River in 1798 by Reverend McGregor; by 1807 a small seam was being worked.

From 1826 to 1857, the General Mining Association (GMA) held a virtual monopoly on the Province's coal resources under a lease from the Duke of York, who had been granted the right to all minerals in Nova Scotia by the British Crown. In 1857, the GMA surrendered much of its monopoly to the Crown and since that time the Province has owned the coal resources of Nova Scotia. With this relinquishment, several new companies became lease holders (Figure 24), thus accelerating the pace of coal development through the nineteenth century in Cumberland, Colchester and Pictou counties.

Figure: (not presently available)
Figure 24. *A group of nineteenth-century entrepreneurs poses before a coal seam outcrop at Broad Cove, Inverness County. NSDME.*

On Cape Breton this development opened the coal-rich Glace Bay district to new operators; by 1870 some twenty collieries were operating (Figure 25). The formation of the Dominion Steel and Coal Company (Dosco) in 1893 consolidated operations in the Glace Bay-New Waterford districts. Meanwhile the GMA continued to operate at Sydney Mines until 1900, when it was succeeded by the Nova Scotia Steel and Coal Company. Peak production was reached in the mid-1940s, but the post-war period brought a steady decline; by 1960 only half of the original mines were still producing. The Princess colliery, which operated at Sydney Mines from 1908 to 1975; is now open to the public as a miners' museum. Roughly one hundred mines have been opened in the Sydney coalfield, more than in any other field in Nova Scotia.

Figure: (not presently available)
Figure 25. *The Caledonia colliery, which operated at Glace Bay in the Sydney coalfield from 1864 to 1892. Nova Scotia Museum.*

On the west coast of Cape Breton, the Cape Breton Coal Mining Company commenced mining at Port Hood in 1865. Mining began the same year at Inverness, and commenced at Chimney Corner in 1867. During the late nineteenth century, mining was sporadic in these areas. At Broad Cove, the Broad Cove Coal Company was engaged in small-scale mining during this time.

Various attempts were made to develop mines in the geologically complex Mabou coal district during the late 1800s and early 1900s by companies such as Port Hood Collieries Ltd. and the Eastern Trust Company. In 1961, the Scotian Coal Company Limited once again attempted to develop a mine at Mabou but abandoned this project in 1964.

During the early twentieth century, Port Hood Collieries Limited and Inverness Railway and Company operated miens at Port Hood and Inverness. In 1947, the St. Rose mine began operation, and continues to operate today, under the direction of Evans Coal Mines Ltd.

The Pictou coalfield is one of the most extensively worked area of the Province in relation to its size. The original Acadia Coal Company was formed in 1864; however the General Mining Association continued operations until it sold its rights to the Halifax Coal Company in 1872. Several other companies were involved in mining the Pictou coalfield during this period, including the Intercolonial Coal Company, the Montreal and Pictou Company, and

numerous others (Figure 26). The Acadia, Halifax, and Vale companies merged in 1886 to form a new Acadia Coal Company was the major mining-concern, although many others worked seams in various parts of the county (Figure 27).

Figure: (Not presently available)
Figure 26. *The Foord pit, Albion Mines (now Stellarton), Pictou coalfield, circa 1870-1880. The ruins of the Cornish Pump House (the major stone structure) can be seen today along the Trans-Canada Highway between New Glasgow and Stellarton. Courtesy of Stellarton Miner's Museum Geological map of the Sydney coalfield.*

Figure: (Not presently available)
Figure 27. *Nova Scotia Department of Mines drill no. 1. Which was used to drill for oil shale at McLellan's Brook, Pictou Coalfield in 1926; J. P. Messervey Idealized stratigraphic column of the Sydney coalfield showing major coal seams.*

The Intercolonial Coal Company continued operation of the Drummond colliery at Westville, well past the colonial era from which its name is derived, until purchased by the Drummond Coal Company in 1961. (The mine, purchased by Pioneer Coal Co. in 1983, closed in 1984 due to a fire underground.) The brick buildings of the Drummond, now showing signs of age, are a testament to the grandeur of the industry early in this century, when everything from side-tip rail cars to the bricks themselves were manufactured on site.

Many of these companies were instrumental in building railways to connect with the Intercolonial Railway, opening previously inaccessible areas of the Province. It was the General Mining Association which in 1839 utilized the steam locomotive Samson for the first industrial railway in Canada, which ran between Albion Mines (Stellarton) and the wharves at Dunbar Point on the Northumberland Strait.

In Cumberland County, many companies opened small mines in the Joggins-Chignecto coalfield after 1858, but these did not flourish due to transportation problems. Soon after the Intercolonial Railway opened in 1872, coal mining increased significantly at Springhill. In 1879, the Springhill and Parrsboro Railway Company (SPRC) received mining rights from the GMA, and five years later, SPRC was succeeded by the Cumberland Railway and Coal Company (Figure 28). The management of the latter company was taken over in 1917 by the Dominion Steel and Coal Company, operators of mines in the Sydney coalfield. The old Syndicate mine, operated by an American syndicate in the 1880s and by Springhill Coal Mines Ltd. During the 1960s, is now a miner's museum.

Figure: (not presently available)
Figure 28. *A Cumberland Railway and Coal Company drill exploring for coal at Rodney (Springhill coalfield) in 1913 (drillhole CRCC32). Courtesy of Mrs. Daniel Davis Geological map of the Sydney coalfield.*

In 1887, the connection of the Maccan-Joggins railway with the Intercolonial Railway led to an increase in mining in the Joggins-Chignecto coalfields (Figure 29). The Joggins Coal Company Ltd, and the Maritime Coal Railway and Power Company were the major operators in this area. The Cochrane mine of the River Hebert Coal Co. at River Hebert was the last of approximately fifty underground mines in the coalfield; it ceased operations in 1980.

Figure: (not presently available)
Figure 29. *Joggins, Cumberland County, circa 1900. Nova Scotia Museum.*

Small mining operations also took place in the less-extensive coal districts of the Province. The Colchester Coal and Railway Company operated a mine in the Debert-Kemptown coalfield of Colchester County from 1903 to 1910. A mine at Kemptown was in production from 1920 to 1932, one at Belmont in 1925. In the River Inhabitants Basin of Cape Breton, the Tidewater Fuel and Navigation Company operated a mine at Whiteside in 1928, one of three short-lived ventures undertaken by companies there. At Glengarry, Cape Breton Island, very minor attempts at mining coal were made before and during the 1930s.

Underground coal mining historically has included stories of tragic disasters and brave rescue efforts. In the Springhill coalfield, the phenomenon of rock bursts or "bumps" claimed many lives, and the worst of these, in 1958, signalled an end to major coal mining there. In the Pictou coalfield, the tendency of seams to undergo spontaneous combustion resulted in several tragic fires and explosions. In all coalfields, mechanical failure or human error has added to the list of misfortunes.

Despite ever-present dangers, coal mining prospered throughout Nova Scotia during the first half of the twentieth century. By the late 1950s, however, coal mining in the Province experienced a sharp decline because abundant, inexpensive imported oil was replacing coal in many of its traditional industrial and domestic markets. High transportation costs to the central Canadian market also helped make Nova Scotia's coal noncompetitive. Mining in the once prolific Springhill and Pictou coalfields came to a virtual standstill, although smaller operations continued in the River Hebert, Pictou and western Cape Breton coalfields.

The formation of a federal Crown agency, the Cape Breton Development Corporation (CBDC), in 1966 eventually led to a revitalization of the coal-mining industry in the Sydney coalfield CBDC initially incorporated the Dominion Steel and Coal Company and the Nova Scotia Steel Coal Company. Several smaller, independent operators were later absorbed.

With the upheaval in the world energy situation during the late 1970s, interest in the Province's coal resources was rejuvenated. The Cape Breton Development Corporation has, with the aid of the Nova Scotia Department of Mines and Energy, begun work on the expansion of underground mining in the Sydney coalfield. Given the volatile and at times, unstable status of available energy resources, the Coal Section of the Nova Scotia Department of Mines and Energy has delineated several emergency supply sites where coal could be mined quickly through open-pit operations should the need arise.

Exploration and development of the Province's known coal resources is ongoing, a strong indication that the long history of coal mining in Nova Scotia will continue.

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5. Modern Coal-Mining Methods

The methods employed in mining the coal resources of the Province have evolved over many years in response to a variety of geological, economic and engineering factors. The room and pillar method of mining has changed little throughout the years. The longwall methods introduced to the Drummond colliery in 1899, has witnessed dramatic technological improvements to equipment; fully mechanical longwall mining was introduced in the Sydney coalfield in the early 1970s. Recent innovations, such as the development of the tunnel-boring machine used to drive access tunnels at Donkin (Figure 30), are shaping the future of Nova Scotian and international mining methods.

Figure: (not presently available)
Figure 30. *The tunnel-boring machine used to drive exploration slopes at Donkin, Sydney coalfield. Owen Fitzgerald.*

Each coalfield has particular economic, geotechnical and environmental considerations that must be addressed in determining the mineability of its resources. The ultimate goal is to economically extract the maximum amount of coal from each deposit. It is of equal importance that the mining be carried out in the safest manner and at the lowest environmental cost.

The viability of mining a particular seam of coal is dependent upon the following factors:

1. the thickness and quality of the coal seam;
2. the volume of coal that can be feasibly recovered once mining engineering criteria have been considered;
3. the vertical depth of the seam below ground level or, in submarine areas, below sea level;
4. the environmental effects of mining the seam; and
5. the economic factors, including the production costs of mining the seam and the market for the coal.

The mining method depends on the depth of the coal seam from surface. If the seam lies at great depth (usually in excess of 100 m) with *competent* strata overlying it, underground mining methods are used. If the seam lies at shallow depths with a minimum of *overburden,* surface-mining methods are employed.

When underground mining methods are used, access to the coal reserve is grained by inclined tunnels or *slopes,* or by sinking vertical *shafts.* Slope mines have multiple-entry systems for ventilating the mine workings, transporting men and materials, and for the conveyance of coal from the production area to surface. If shaft mining is used, coal is transported to the surface using an elevator or hoist system. Separate shafts are normally used to facilitate ventilation of the mine workings.

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Underground Mining Methods

Underground mining is responsible for approximately 94 percent of the coal produced in Nova Scotia. The remaining 6 percent is produced using surface-mining techniques. The main methods used in underground mining are:

1. advance longwall,
2. retreat longwall and
3. room and pillar.

Advance Longwall

Longwall mining is applicable to mining extensive, thin-to-moderately-thick coal seams. It is used most readily in coal deposits not subject to sudden changes in dip, thickness or elevation and directly overlain by strata many times the thickness of the coal seam. This method relies on complete subsidence of the worked-out area, with strata overlying the coal seam readily caving behind the production *face.*

The production of coal takes place along a face, or "wall", blocked out between two panel entries (a *panel* is a rectangular block, or pillar, of coal, the size of which is determined by the surrounding workings.) A pillar of coal is left intact between main passageways and the workings. Steel arches and hardwood packs provide the panel entries with roof support and protect them from caved waste material in the production area.

In the advance longwall method, coal is removed by a shearer, a powerful set of breaking tools (Figure 31) forced against the face of the coal seam hydraulically and pulled laterally across the width of the panel. The shearer consists

of rotating drums, faced with cutting bits, that are capable of being raised or lowered depending on seam thickness. The shearer operator moves with the machines as it advances along the face. The broken coal is deposited on a face conveyor running parallel to the face, discharged onto a stage loader, and conveyed back to the main mine entry and finally to surface.

Figure: (not presently available)
Figure 31. *A face shearer and operator, with shields overhead, at the coal face of an advance longwall in the Lingan colliery, Owen Fitzgerald.*

Hydraulically powered, self-advancing roof supports are used behind the cutting face to support the roof, keep the face open, and at the same time to permit the roof to break and cave immediately behind the support line with each face advance. This permits most of the weight of overlying strata to rest on the broken waste material as mining advances. The conveying, cutting, roof-support, and guidance systems are advanced hydraulically after each pass of the shearer.

Production costs per tonne of coal are generally lower with the longwall method than with the room and pillar method, due to fewer roof-control problems, lower roof-support costs, reduced maintenance costs, more dust control and a higher tonnage yield per man. Ventilation problems are greatly reduced, as the air must be coursed over only one working area; other types of mining require air to be passed through several areas. In addition, the training of personnel for longwall mining can be accomplished more quickly than the training required for room and pillar mining.

Retreat Longwall

Retreat longwall mining is used in coal seams with fragile roof and floor conditions. The entire coal panel is developed with two parallel entries prior to mining. Longwall mining begins at the outer limit of the coal panel and "retreats" back toward the mine slope or main entries. The direction of mining is essentially the reverse of that in the advance longwall method; the cutting, support and conveyance systems used are the same. Mining terminates when the proposed coal pillar between the workings and main entries has been reached.

The disadvantage of this method is that the lead time from development to production is greater than in advance longwall mining.

Room and Pillar

Room and pillar mining, also termed "bord and pillar," involves driving openings to divide the coal into rectangular or square blocks (Figure 32). These blocks, or pillars, provide support for the overlying strata. They are temporary in cases where pillars are to be recovered, or permanent if pillars are to be left intact. This method is suited to areas where the main roof is strong enough to span the desired room width. A moderately-firm floor is desirable. The maximum practical depth for this type of mining depends on the strength of the pillars; in coal mining this depth is generally less than 300 m.

Figure: (not presently available)
Figure 32. *Underground workings of the Drummond mine, Pictou coalfield.*

Room and pillar coal mining allows a greater degree of flexibility and selectivity than longwall mining. Starting or stopping development of a specific area is a fairly simple matter. Several areas can be developed simultaneously. If any area is stopped, alternative areas can be worked. Compared to longwall mining, costs for room and pillar are

higher for ventilation, equipment and materials, and dust control. There is also more difficulty in supplying power and water, delivering supplies, and dewatering the mine workings. This method is more wasteful because more coal must be left unmined than with longwall methods.

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Surface Mining

Area surface mining has been used in recent years in Nova Scotia to recover the near-surface fraction of several coal seams. This method requires the removal of vegetation, unconsolidated *glacial till* and waste rock overlying the coal seam. The overburden is removed and piled alongside the excavated area using *dragline* or earth-scraper machines. If necessary, competent strata overlying the seam are drilled and blasted prior to removal. The open-pit operation continues until the coal seam is exposed. The coal is then mined using front-end loaders and hauled from the mine site by trucks (Figure 33).

Figure: (not presently available)
Figure 33. *A small-scale open-pit coal mine (Foord seam test open-pit. Pictou coalfield, 1978). NSDME.*

The maximum mining depth for open-pit mining is determined by the ratio of the volume of overburden overlying the seam to the amount of recoverable coal in the seam. When the cost of removing the overburden becomes too great in relation to the price realized for the mined coal, a "cut-off" mining-depth limit is established.

Surface mining of coal is a temporary land use. When mining ceases, the site must be reclaimed by the proper grading of waste piles, providing good drainage, conditioning the soil and planting. Through proper reclamation the site can be returned to a state similar to its original state and supportive of the same plant and animal life that existed prior to mining.

The advantages of mining coal by this method are substantial. Producing coal by surface-mining methods costs less than underground methods. Less manpower and equipment are required and surface mines are generally safer.

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6. Coal Production and Utilization in Nova Scotia

Nova Scotia contains an estimated coal resource of 3 billion tonnes. The major portion of the resource is found in the Sydney coalfield (2.65 billion tonnes). The next largest fields are those at Mabou (143 million tonnes). Springhill (77 million tonnes) and Pictou County (70 million tonnes). The remaining coalfields contain resources totalling approximately 16 million tonnes. It should be noted that less than 20 percent of the resource is classified as measured (proven), indicating that much is yet to be learned about the Province's coal resources. Recoverable coal (*reserves*) is estimated at one billion tonnes.

The bulk of metallurgical-grade coal is contained in the Harbour and Phalen seams in the Sydney coalfield, although a smaller resource exists in the Acadia seam in the Pictou coalfield Metallurgical-grade coal is determined by several quality characteristics such as sulphur and ash content. Another factor in determining the grade of coal is its amenability to sulphur reduction through *beneficiation*. Since washability tests have not been completed on all coals with metallurgical-grade properties, it is not known if all reserves of metallurgical-grade coal can meet market specifications. Therefore, only rough estimates can be given for resource tonnages of metallurgical-grade coals in the Province. The current estimate is between 200 and 250 million tonnes.

There are six companies producing coal in Nova Scotia including a company involved in mine waste-bank ("dump") reclamation (Table 2).

Table 2. Raw Coal Production and Employment in Coal Mines of Nova Scotia

Companies Producing Coal in Nova Scotia

Company	Mine/Operation	Location	Raw Coal Production 1983 (tonnes)	Raw Coal Production 1984 (tonnes)
Cape Breton Development Corporation	1. Lingan mine 2. Prince mine 3. No. 26[1]	New Waterford Point Aconi Glace Bay	1,8000,000 777,000 890,000	1,895,341 966,151 289,239
Pioneer Coal Co. (Formerly Drummond)	Drummond mine[2]	Westville	12,600	39,468
Novaco Limited	Novaco surface mine	Point Aconi (and Springhill 1983)	215,000	139,283
Evans Coal Co.	Evans mine	St. Rose	43,500	46,283
T. Brogan & Sons Construction	Brogan surface mine	Point Aconi	30,500	45,543
Selminco Inc.	dump reclamation	New Waterford Sydney Mines	121,200	124,934
		Total	3,890,400	3,546,172

[1]No. 26 mine ceased production in April 1984 due to an underground fire.

[2]The Drummond colliery (underground) ceased production in August 1984 due to an underground fire.

Employment in Nova Scotia Coal Mines (1983)

Company	Employees	
Cape Breton Development Corporation	4,450	(includes staff for all coal-related activities)
Evans Coal Company	53	
Pioneer Coal Co. (formerly Drummond)	40	
Novaco Limited	23	
Selminco Inc.	60	
T. Brogan & Sons Construction	10	
Total	4,636	

The Cape Breton Development Corporation (CBDC) is the largest producer of coal in Nova Scotia with two operating mines in the Sydney coalfield with a yearly combined output capacity of 2.75 million tonnes of raw coal. The third CBDC mine, No. 26 colliery, ceased production in April 1984 due to an underground fire.

The Lingan mine (Figure 34), located in the New Waterford area, was opened by CBDC in 1967 to extract coal from the Harbour seam. This submarine colliery operates with three advance longwall systems serviced by four slopes. The

resource available to this mine is 71 million tonnes, and with a rate of extraction of 60 percent, has potential reserves of 43 million tonnes. Production of raw coal in 1984 was 1,895,000 tonnes, most of which was processed at the Victoria Junction Coal Preparation Plant. Fifty to sixty percent of cleaned, saleable coal is of metallurgical grade, while the coal referred to as "the middlings" is sold in the *thermal coal* market. Over 20 percent of the raw coal feed is rejected to waste banks. The Lingan mine is expected to continue producing coal at a rate of 1.38 million tonnes of saleable coal per year.

Figure: (not presently available)
Figure 34. *The Lingan colliery of the Cape Breton Development Corporation at New Waterford, Cape Breton. Owen Fitzgerald.*

The Prince mine (Figure 35), located in the Point Aconi area, is another CBDC mine in operation in the Sydney coalfield of Cape Breton. The Prince is a submarine mine that extracts coal from the Hub seam by two retreat longwall systems, serviced by two slopes extending under the Atlantic Ocean. The resource available to the mine is 70 million tonnes. At sixty-percent extraction, the Prince mine has reserves of 42 million tonnes. Production of raw coal in 1984 was 966,000 tonnes, all of which was sold directly in the thermal coal market. Prince mine is expected to continue producing approximately 1 million tonnes of raw coal per year. The discovery of an increase in inorganic partings and a higher ash content within coal in the western region of the mine reserve has led to the planned addition of a wash plant at the mine site, and will result in a reduction of saleable coal.

Figure: (not presently available)
Figure 35. *The Prince mine of the Cape Breton Development Corporation at Point Aconi, Sydney coalfield. Owen Fitzgerald.*

Prior to an underground fire in April 1984, CBDC's oldest operating mine was No. 26 colliery in Glace Bay. In operation since 1944, No. 26 operated from the shaft of No. 1B colliery which opened in 1924. No. 26 mine produced approximately 890,000 tonnes of coal in 1983 from two advance longwall faces, however, due to the fire it produced only 289,000 tonnes in 1984.

The Evans mine is located in the St. Rose-Inverness coalfield on the western shore of Cape Breton, 16 km north of Inverness (Figure 36). This small underground mine extracts coal from the No. 5 seam of the St. Rose coal district. A conventional room-and-pillar operation serviced by two slopes, it produced approximately 46,200 tonnes of raw coal in 1984, most of which was sold in the thermal and domestic markets within the Province. Under a recent agreement with the Government of Canada. Evans agreed to undertake a capital development program at a cost of 1.5 million dollars, to increase productivity and improve safety. Production is expected to increase in future to 60,000 tonnes per year.

Figure: (not presently available)
Figure 36. *The Evans mine at St. Rose, Cape Breton, Nova Scotia Department of Education, Media Services.*

T. Brogan and Sons Limited operates a small surface mine in the Point Aconi area of Cape Breton. Mining operations are carried out on the Upper and Lower Bonar seams by conventional, small-scale dragline. Production in 1984 was 45,543 tonnes of raw coal, most of which was sold in the thermal and domestic markets within the Province. The total reserve is estimated at 225,000 tonnes.

Pioneer Coal Company, a subsidiary of Nova Construction Company Limited of Antigonish, obtained the Drummond

colliery in the Westville area of Pictou County in early 1984. Pioneer has estimated that the reserves are 453,500 tonnes of near-surface coal. 272,100 tonnes of underground coal, and a further 453,500 tonnes of coal that may be recoverable from waste banks on the property.

The old Drummond colliery mined coal from the Acadia and Scott seams continually from 1868 to 1984, when underground workings ceased. Exploration has identified a small additional underground resource available along *strike* to the southeast of the Drummond colliery.

Recovery of coal from the old mine dumps is planned by utilizing a modular coal washplant with a capacity of 45 tonnes per hour. The planned annual recoverable tonnage from the dumps is 45,000-50,000 tonnes per year depending upon available markets. The reclamation of the dumps will take place from 1985 to 1995, although the life of the wash plant may be extended if it can be used to upgrade coal from surface and underground operations.

Annual production of saleable coal from Pioneer's operations is estimated at 100,000 tonnes per year for a period of ten to twenty years. The coal from this operation will vary somewhat due to quality differences in:

1. near-surface coal and underground reserves and
2. the Acadia and Scott seams.

Selminco Inc. Operates two coal waste-bank reclamation projects in Cape Breton: one at the Summit waste bank in New Waterford and the other at the Princess waste bank in Sydney Mines; commencement of operations in 1979. Recovery of thermal-grade coal from the dump ranges from 10 to 20 percent. At a processing rate of 43,350 tonnes per year, the Princess dump is expected to be exhausted by 1986. Plant life may be extended a year by trucking in dump material from nearby areas. Negotiations with the Cape Breton Development Corporation are underway regarding access to an additional waste bank.

The Summit dump in New Waterford contained about 3 million tonnes of raw material prior to the reclamation that began in 1982. Recovery rates and coal quality from the Summit dump are similar to the Sydney Mines operation, but the capacity of the New Waterford plant is greater. At a rate of 54,420 tonnes of recovered coal per year, the Summit dump is expected to be exhausted by 1987. Production from both sites in 1984 totalled 125,000 tonnes. The plant could be utilized an additional year or more by trucking raw material from other sites.

Novaco Limited, a wholly owned subsidiary of Nova Scotia Resources Limited, became involved with surface coal mining in late 1979. Novaco generated a mine on the Sydney Main seam or Harbour seam) in the Point Aconi area (Figure 37) whose reserves are nearly depleted. Novaco's total coal production in 1983 was 237,000 tonnes, which included approximately 15,000 tonnes from a smaller surface operation on the Rodney seam in Springhill. The Springhill operation had been directed toward obtaining information for evaluating underground mining possibilities, and after producing approximately 83,000 tonnes, was completed in August 1983. Novaco's production in 1984 was solely achieved from the Point Aconi site, where 139,000 tonnes were mined.

Figure: (not presently available)
Figure 37. *Dragline operating at the Novaco open-pit mine at Point Aconi. NSDME.*

The major user of Nova Scotian coal is the Nova Scotia Power Corporation (Figure 38). Other consumers within the Province include the Sydney Steel plant, boilers in industrial plants, and other Canadian provinces. Seventy-eight percent of the coal was utilized in Nova Scotia, greatly aiding the effort to lessen our reliance on foreign oil imports. A breakdown of coal disposition in 1983 and 1984 is given in Table 3.

Figure: (not presently available)

Figure 38. *The Lingan power plant of the Nova Scotia Power Corporation at Lingan, near New Waterford, Cape Breton. Owen Fitzgerald.*

Table 3.	**The Disposition of Nova Scotian Coal Markets, 1983 and 1984.** (Preliminary figures in tonnes after processing)		
		1983	**1984**
Deliveries to Nova Scotia Power Corp.		1,740,743	2,196,259
Domestic		52,626	49,267
Industrial		34,101	44,192
	Total Disposition in Nova Scotia	1,921,643	2,289,718
To Other Provinces		51,453	26,638
	Total Disposition in Canada	1,973,096	2,316,356
Exports (total)		1,109,263	499,174
Itemized:	Argentina	19,402	-
	Belgium-Luxembourg	15,386	-
	Brazil	266,938	162,211
	Greece	100,187	-
	Italy	70,011	26,313
	Japan	49,864	76,104
	Netherlands	71,780	60,351
	South Korea	105,865	76,466
	Sweden	118,336	28,872
	France	-	25,435
	West Germany	291,494	43,422
	Total Disposition	3,082,359	2,815,530

Offshore markets for Nova Scotia coal in 1983 and/or 1984 included Brazil, West Germany, South Korea, Sweden, the Netherlands, Japan, Greece, Italy, France, Argentina, Belgium and Luxembourg. The Cape Breton Development Corporation is pursuing markets in other countries such as Mexico. Taiwan, Spain, Finland, Denmark and Jamaica. The economic activity spawned by coal mining in Nova Scotia includes direct wages of approximately $59 million and yearly sales of about $140 million.

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Coal Preparation

The Cape Breton Development Corporation operates the only complete coal-treatment facility in Nova Scotia (Figure 39) at its Victoria Junction plant at Grand Lake. This plant, commissioned in 1976, employs 43 salaried and 154 hourly employees in a 231-day year. It treats 680 t/hr in two parallel circuits, which receive coal from the Lingan mine by rail. "Fines" (coal smaller than -28 *mesh*) are processed by froth flotation, and the +28 mesh to 4 cm size is treated by heavy-media washing *cyclones*. Both circuits produce metallurgical-grade coal, thermal-grade coal and rejected material.

Figure: (not presently available)
Figure 39. *The Victoria Junction coal preparation plant of the Cape Breton Development Corporation. Owen Fitzgerald.*

Given the variation in sulphur content of the coal fed from the Lingan mine, the option exists to reduce the maximum size to 2 cm to create a greater liberation of pyrite, and hence sulphur. This must be balanced against greater retained moisture on the increased surface area. At present, coal and discarded waste dewatering is completed through the use of a centrifuge. In future, fine coal recovered by flotation will be dewatered with disc filters. Additional magnetic separators will be installed to improve recovery of the magnetite utilized to provide the heavy media for washing cyclones. As well, discarded material (+28 mesh to 15 cm) handling capacity will be increased by 50 percent.

Selminco Inc. is recovering coal from waste dumps at Sydney Mines and New Waterford. Coal is separated from the waste rock in raw material, or "feed," by screening off the coarse, rejected fraction, by conditioning/breaking and by water-only cyclones. Coal recovery is approximately 10 percent of the feed material processed. The large amount of waste is returned to areas of the waste dumps which have been already removed, and the dewatered thermal-coal product is shipped by rail and/or truck to CBDC.

Coal production for the 1983 calendar year amounted to 57,000 tonnes (1.9 percent sulphur, less than 9.0 percent ash, and 7.0 percent water) from the Sydney Mines plant and 63,000 tonnes (1.5 percent sulphur, less than 9.0 percent ash, and 7.0 percent water) from the Summit mine waste-bank plant. The future improvements envisioned are early removal of coarse rejected fraction and recycling of rejected material from the cyclone. Each plant employs five salaried personnel and general contractors provide 24 operators for 5 days/week 24 hour/day operations. A general manager oversees both operations.

Gael Tech. Inc., an operating subsidiary of Guildcraft Inc. of Toronto, is establishing a plant of the Princess Mine dump at Sydney Mines. The objective is to recover fine coal from the fine tailing of the former wash plant by employing *spherical agglomeration* and special screening techniques.

Photo: (Not presently available)
Mining equipment

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7. Role of the Province of Nova Scotia

The people of Nova Scotia own the coal resource of the Province. The Nova Scotia Department of Mines and Energy (NSDME) is responsible for the effective evaluation, promotion and control of the development and use of Nova Scotia's coal resources for the optimum economic and social benefit of the Province. The first priority of coal development is to provide the coal needed to reduce Nova Scotia's dependence on imported oil for electrical generation and other energy requirements. Coal development must make optimum use of Nova Scotia's manpower, materials and equipment, and the people of Nova Scotia must obtain a proper share of coal revenue by way of royalty. Attractive returns to industry must exist as an incentive to explore and develop this resource.

The Province is responsible for inspections and regulations regarding mine developments and operations to ensure compliance with safety, industrial-health, environmental and resource-conservation standards.

The Coal Section (formerly the Coal Inventory Survey) of the Department was formed in 1974 to evaluate the coal resources of the Province, chiefly from a cataloguing standpoint, through diamond drilling. Since that time, the

activities of the Coal Section have expanded and evolved to include applied geological research and exploration programs in an effort to support and promote development of the Province's coal resources. The Department of Mines and Energy is actively involved in the promotion of coal-related research and development to facilitate the use of new technological advancements in coal development and utilization within the provincial coal industry.

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The Coal Section of the Department of Mines and Energy

The Coal Section, part of the Energy Resources Division of the NSDME, is an integrated group with expertise in the fields of coal geology, utilization and development. The primary objective of the Coal Section is to encourage and coordinate the development and efficient use of coal and peat. Its primary duty is the undertaking and coordination of applied research to aid and promote development of the Province's coal resource by expanding our knowledge of Nova Scotia coals, from their origin and geological character to their ultimate utilization.

The roots of the Coal Section go back to 1974 when the Coal Inventory Survey was brought into existence under a three-year agreement with the federal Department of Regional Economic Expansion (DREE). Previously, no one group had been responsible for maintaining or gathering data on the various coalfields. The purpose of the Coal Inventory Survey, as its name implies, was to investigate the Province's coal resources to outline deposits amenable to underground mining and, later, to delineate near-surface resources; its chief method was diamond drilling. It began as a work being undertaken had become increasingly more diverse and involved. This change developed in response to an increased demand for supportive expertise by the coal industry and the realization that documentation of the resources of our coalfields required a deeper understanding of geology than offered by a simple inventory.

While the coal survey was beginning to mature in the depth and scope of its investigations, new developments in coal utilization began to occur. With the energy crisis of 1979-1980, the role that coal, our most important and accessible indigenous energy source, was to play in the Province's energy plan became crucial. The Provincial Energy Task Force and its report "Energy, a plan for Nova Scotia," underlined the importance of coal and gave impetus to increased investigation and promotion of this resource.

Simultaneously, the Coal Section grew to include the monitoring and initiation of utilization and development projects. It evolved into an integrated group possessing an increased knowledge of the many aspects of our coal resources. Although continually inter-related, the activities of the Coal Section may be divided, for the sake of discussion, into four areas; applied coal research and exploration, oil shale evaluation, coal development and utilization, and a peatland inventory program.

Applied Coal Research and Exploration

The geological evaluation and understanding of the Province's coalfields and coal seams requires a multi-faceted approach. The Coal Section uses diamond drilling as the primary source of data acquisition and supplements it with disciplines such as geological mapping (Figure 40), structural interpretation, coal petrography, and geophysical methods. The interpretation of depositional environments made possible by these methods is an important facet of the Coal Section's work because it permits the geologist to scientifically predict and understand occurrence, composition, and quality trends of our coal resources.

These studies are necessary, not only to correlate coal seams and delineate coal basins but to understand our coal resources to promote future exploration and development and advances in utilization research.

Figure: (not presently available)
Figure 40. *Geologists mapping the Foord seam, Pictou coalfield. NSDME.*

Oil Shale Evaluation

The evaluation of our oil shale resource will follow many of the lines of investigation mentioned above. The most promising oil shales, at this point in our understanding, are intimately associated with the coal seams of the Pictou coalfield. Significant deposits have also been identified in the Big Marsh area of Antigonish County. The Coal Section is mounting a substantial investigation of these largely undocumented shales to create a better understanding of their geological setting and allow more enlightened estimations.

Coal Development and Utilization

Coal is one of the most important resources of the Province's mining industry, and the future of coal in the medium to long term will depend upon diversification of its utilization and the development of optimum mining, handling and transportation systems. The Coal Section monitors all research and development activity in the Province related to coal utilization to evaluate its applications to the Nova Scotia coal industry. The Section is involved with various facets of this activity, including coal *liquefaction, fluidized-* bed combustion and coal-liquid mixtures (these techniques are discussed in Chapter 8).

An important task of the Coal Section is the identification of problem areas and the direction of new research toward solving these. Coal transportation and markets, blending facilities, optimum use of existing infrastructure, cost-effective means of reducing combustion emissions, market competition with alternate fuels, and geological research into new exploration areas and existing mines are just a few of the problems facing the coal industry in the Province that the Department is addressing.

Peatland Inventory Program

Through the Coal Section, the Nova Scotia Department of Mines and Energy conducted an inventory of fuel peat in the Province's peat bogs from 1980 to 1984. Preliminary figures suggest that fuel peat reserves within the Province are in the order of several hundred million tonnes. Peat, as a precursor to coal, contains a considerably higher percentage of moisture. However, at 50 percent moisture, peat from the inventoried bogs typically possesses a calorific value of 14-18.6 MJ/g (6000-8000 BTU/lb), similar to that of lignite.

Coal Exploration Licenses

One of the roles of the Coal Section is to evaluate, from a technical standpoint, coal exploration proposals from the private sector to ensure that the resource will be developed with minimum waste and maximum advantage to the people of Nova Scotia and the coal industry. Table 4 is a flow chart of procedures followed in application for a special coal exploration license.

The conditions for a representative special license are outlined in Table 5.

Table 4. Special Licensing Procedure to Explore for Coal in Nova Scotia.	
Company	**Province**
(A) Company applies to Registrar of Mineral Rights for special license stating area, tract and claims desired.	
	(B) If ground is open for special license, registrar accepts application and advises company of Acts and conditions that are applicable. If other licenses are held on the area, registrar review situations with directors involved.
(C) Company submits a copy of the proposed exploration program to the registrar.	

	(D) Registrar sends proposal to Director of Energy Resources for review, who in turn solicits comments from other divisions within the Department and from other departments.
(E) Company meets with Department officials to discuss proposal.	
	(F) Director of Energy Resources makes recommendation to Deputy Minister and Minister on the proposal regarding approval/disapproval as well as suggested terms and conditions, if approved.
(G) Company review, approves and returns special license.	
	(H) Minister submits memorandum to Executive Council recommending approval of special license. If approved, Governor-in-Council authorizes issuance of special license.
(I) Company signs special license.	
	(J) Minister signs special license.

Table 5. Conditions Included in a Representative Special License for Coal Exploration in Nova Scotia

General Conditions

- terms of license and renewals
- rental fee
- value of expenditures on work program

Exploration Conditions

- description of work program
- reporting procedures
- drill core and drill procedure

Development Conditions

- marketing conditions
- Nova Scotia benefits
- royalty provisions
- provincial participation provisions

Other Conditions

- except as stipulated in this license, all other provisions of the Mineral Resources Act shall apply as if they were part of this license

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The Mines and Minerals Branch of the Department of Mines and Energy

The Mineral Resources Division

The mandate of the Mineral Resources Division is understanding and describing the Province's geology and mineral resources. A continuing part of this same mandate is the development of projects to describe the regional geological settings of the Carboniferous basins of Nova Scotia. This research encompasses studies of regional stratigraphy in cooperation with the Geological Survey of Canada and university personnel, and parallels the applied coal-geology studies of the Province's coalfields by the Coal Section of the Energy Resources Division.

A project to update the understanding of the regional stratigraphy of the Sydney basin was undertaken under the Canada-Nova Scotia Co-Operative Mineral Agreement 1981-84. A result of this project will be publication of an updated series of geological maps for the basin at a scale of 1:50 000. Similar regional projects are currently being implemented under the terms of the Canada-Nova Scotia Mineral Development Agreement for the Cumberland and Pictou (Stellarton) basins.

The Mining Engineering Division

The Mining Engineering Division is responsible for the administration and regulation of the coal-mining industry in the Province on behalf of the Department of Mines and Energy. These functions include the approval of new, and modifications to existing, mining projects; responsibility for occupational health and safety of workers; protection of the environment; and efficient use of the Province's coal resources. Inspection of underground and surface coal mines is an important method for carrying out these responsibilities. The Division provides diamond-drilling services to the Energy Resources and Mineral Resources divisions of the Department and to other government departments. These services are used extensively in coal exploration programs by the Coal Section.

Photos: (Not presently available)
Miners

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8. Coal Utilization Research in Nova Scotia

The coal research and development community in the Province is very active in a variety of projects and programs directed at all aspects of the coal industry. Funding for coal utilization research comes from a variety of federal and provincial departments and from the private sector. Many of the Maritime universities are involved in these coal research and development programs. The Committee on Atlantic Coal has recently been formed as a vehicle to bring research scientists together to exchange ideas and information. Working groups in coal *pyrolysis,* coal-liquid mixtures, coal beneficiation and coal mining/safety have been formed under the auspices of the Committee on Atlantic Coal. (See Appendix 2 for a list of Committee on Atlantic Coal projects for 1984-1985.)

Coal liquefaction, coal beneficiation for sulphur and ash removal, coal pyrolysis, chemical and bacteriological cleaning of coal, coal combustion, and health and safety in coal mines are but a few of the projects under study at the present time. Much of our thermal-grade coal is high volatile A bituminous. It may range in quality from approximately 8 percent ash, 3 or more percent sulphur, and a calorific value of 30.24 MJ/kg (13,000 BTU/lb) in some areas of the Sydney coalfield, to 25 percent ash, 1 or less percent sulphur and 25.59 MJ/kg (11,000 BTU/lb) in areas of the Pictou coalfield. These variable characteristics of our coal present the research community with new challenges with regard to combustion techniques, beneficiation and utilization options. Much of the research work has as its primary objective the removal of sulphur, either before or during combustion. Investigations into various techniques to achieve this end have resulted in new utilization possibilities.

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Coal Liquefaction

In 1981, Scotia Coal Synfuels, a consortium of privately and publicly owned companies, was formed to determine the commercial viability of a coal liquefaction facility in Nova Scotia. Tests to date indicate the technical practicality of producing a highly marketable transportation fuel product from the liquefaction of Nova Scotia coals.

Nova Scotia is particularly interested in the progress of the liquefaction program due to the fact that in 1982 about 40 percent of petroleum consumption in Nova Scotia was in the transportation sector.

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Coal-Liquid Mixtures

Pulverizing coal to remove pyritic sulphur leads to the problem of handling and transporting fine coal. The coal-liquid mixture approach is one way of resolving this problem; two variations on this theme are under investigation in Nova Scotia. Scotia Liquicoal Ltd., a privately owned Nova Scotian company with a pilot plant in Dartmouth, has been involved in process and product development. Through the utilization of the spherical agglomeration process developed by the National Research Council, the plant can upgrade the quality of coal fed through the plant. Various coal-oil-water mixtures are stabilized by ultrasonic and chemical techniques.

A second coal-liquid mixture under development in the Province is the coal-water product "carbogel," originally developed in Sweden. A new pilot plant to produce this product for combustion-test purposes is located at the Cape Breton Development Corporation's Victoria Junction coal preparation plant.

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Pyrolysis

Pyrolysis of thermal coal is another method of deriving liquid fuels from coal liquefaction. Although the process results in much lower liquid yields than liquefaction, pyrolysis offers greater flexibility in its variety of products. Research is currently underway on pyrolysis of Nova Scotia coals at the Atlantic Research Laboratory and the University of Sherbrooke, Quebec.

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Fluidized-Bed Combustion

Fluidized-bed combustion is a process in which finely divided solid matter is kept in suspension by a current of air or other combinations of gas. This produces a fluidized bed which provides an ideal condition for gas-solid reaction as each particle is in constant motion and in contact with the moving gas stream on all sides.

Coal is one of the more common fuels treated in a fluid-bed combustor. The addition of crushed limestone or dolomite to the coal permits sulphur reduction during combustion. Fluidized-bed combustion is of particular importance to Nova Scotia because of our large reserves of relatively high-sulphur coal.

The Nova Scotia Power Corporation, in cooperation with the federal government is currently carrying out a research program on the application of fluidized-bed technology to Nova Scotia coals at Point Tupper, where a one-square-metre fluidized-bed unit has been constructed. Smaller programs have also been initiated at the Center for Energy Studies with particular attention to the domestic market.

Photo: (Not presently available)
Miners

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9. Future Coal Development Plans

It is conceivable that by 1990 the production of saleable coal from the province will be in the order of 6 million tonnes annually, and by the year 2000 production will be in excess of 8 million tonnes.

The Cape Breton Development Corporation (CBDC) is actively developing new operations in the Sydney coalfield. These plans include the inauguration of a new mine on the Harbour seam on which No. 26 had been operating prior to the fire in early 1984. The new mine, to be called the Glace Bay colliery, is expected to produce 2-2.5 million tonnes of metallurgical-grade coal per year by 1995. In the Lingan area, New Waterford, mining feasibility has been completed with respect to the new Lingan-Phalen mine, which CBDC expects will reach a production level of 1.5 million tonnes annually by the late 1980s (Figure 41).

Figure: (not presently available)
Figure 41. *Slopes being developed for the Lingan-Phalen mine of the Cape Breton Development Corporation, Sydney coalfield. Owen Fitzgerald.*

During the field seasons of 1977-1979, the Department extended its coal exploration drilling to the offshore Sydney and Mabou coalfields. The program, initiated and managed by the Department in consultation with CBDC and the Geological Survey of Canada, was funded jointly by the governments of Nova Scotia and Canada. Nineteen holes were completed offshore in the Sydney coalfield, utilizing ship-shape drilling rigs developed for use in the offshore petroleum industry (Figures 42 and 43).

Figure: (Not presently available)
Figure 42. *Roughnecks working aboard the drillship Glomar Conception, drilling offshore in the Sydney coalfield, 1978. NSDME.*

Figure: (Not presently available)
Figure 43. *The drillship Glomar Conception, engaged by the Department of Mines and Energy in 1978 to undertake offshore exploration in the Sydney coalfield. NSDME.*

The data from this program has resulted in redirection of the Prince mine operation and development of the major Donkin-Morien project by CBDC, both of which will be of long-term benefit to the coal industry and the Province. If feasibility studies at Donkin-Morien are positive, a new mine could be producing coal in the late 1980s and reach 3 million tonnes per year by the mid-1990s. The 3.5 km main exploration slope (Figure 44) is being driven by an innovative tunnel-boring machine designed and built expressly for this project. The tunnel-boring machine is advanced by hydraulic jacks and excavates a 7.6 m diameter tunnel in a single pass. Other possible, smaller-scale coal developments are being evaluated within the Province, and it is hoped that present exploration programs being conducted by private industry and the Coal Section will result in further mining developments.

Figure: (not presently available)
Figure 44. *A view toward surface from within the 7.6 m diameter exploration tunnel driven 3.5 km to the Harbour seam at Donkin, Sydney coalfield. Owen Fitzgerald.*

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Future Export-Market Possibilities

In the late 1970s industrialized nations, determined to reduce their dependence on the cartel of Oil Producing and Exporting Counties (OPEC), were preparing for conversions from oil to coal. Exports of coal to Europe and the Far East were projected to grow at a phenomenal rate. Then, in the early 1980s, the world experienced a recession that affected both the production of steel and the growth of electrical generation, resulting in lower coal prices and a glut of coal on the world market.

As the world comes out of the current recession, it is anticipated that coal demand will strengthen and coal prices will experience an upswing. It is interesting to note that a recent study done by the U.S. Office of Technology Assessment for the U.S. coal industry predicts that coal prices will rise by less than 20 percent by the year 2000. In the same period, however, oil and natural gas prices are projected to increase significantly, thus maintaining coal's edge as a comparatively inexpensive source of energy.

Over the past ten years the Cape Breton Development Corporation has become known and respected as a reliable supplier of coal to the international market. Its coal has been used in coke ovens and steam boilers around the world and is accepted as a product of high quality. CBDC's export projections are 2.7-3.2 million tonnes for 1990 and between 6.3 and 7.3 million tonnes by the year 2000.

The distance to final destination of exported coal is generally over 8,000 km. At these distances the economics of large bulk-carriers prevail, and the shipping industry has responded by providing more vessels in the 100,000 tonne class. Since the draft in Sydney Harbour is insufficient for ships of this size, the Cape Breton Development Corporation will rely heavily on the sheltered ice-free Strait of Canso, which can handle ships of up to 500,000-tonne capacity and has tides of less than 1.5 m.

Nova Scotia coal, which twenty years ago was priced out of the Ontario markets by less expensive American coal, can now effectively compete with U.S. coal in Europe and the Pacific Rim due to our favourable location on the Atlantic seaboard and recent developments in bulk carriers for long-distance ocean transportation. Nova Scotia coal producers are making strides to reduce production costs, increase productivity and produce a high-quality product for sale in the world market. The accomplishment of these goals will ensure our place in the expanding world market for coal.

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Appendix 1. Metric Conversion Table

Whereas the standard form of measure in the Canadian coal-mining industry is metric (Standard International System of units), as adopted by the Mining Association of Canada and the Coal Association of Canada, this form of measure has been used throughout the text. The following conversion factors to the Imperial System are provided for the convenience of the reader.

	multiplied by	
foot	0.3048	Metres (m)
metre	3.28	feet (ft)

mile	1.609	kilometres (km)
kilometre	0.621	miles (m)
short ton (2000 lb)	0.907	tonne (t)
tonne	1.102	short ton (2000 lb)
British thermal unit (BTU)	1.055	joule (J)
joule (J)	0.0009	BTU
BTU per pound	0.0023	megajoule per kilogram (MJ/kg)
megajoule per kilogram (MJ/kg)	429.923	BTU per pound

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Appendix 2. Committee on Atlantic Coal Projects for the 1984/85 Fiscal Year

Beneficiation Working Group	
Investigation of microbiological beneficiation methods	Dalhousie University
Liberation of pyritic sulphur upon grinding	Technical University of Nova Scotia
Pore size distribution	Technical University of Nova Scotia
Investigation of microbiological methods in problems related to the coal industry	Dalhousie University
Desulphurization of coal by bacterial leaching	Atlantic Coal Institute
Beneficiation of coal using controlled pyrolysis	Technical University of Nova Scotia
Mineralogy of sulphur-bearing minerals relevant to cleaning processes	New Brunswick Research and Productivity Council
Effect of ultrasonics in oxydesulphurization	Nova Scotia Research Foundation
Liberation of pyrite in Prince mine coal by grinding in closed circuit with a classifier	Technical University of Nova Scotia
Mineralogy in coal slagging and behavior	New Brunswick Research and Productivity Council
Adsorption properties and porosity versus wetability of coals	Technical University of Nova Scotia
Atlantic Group for Research in Industrial Materials	
Sulphur transfer during pyrolysis	Technical University of Nova Scotia
Vacuum pyrolysis of coals, pilot-scale	University of Sherbrooke, P. Q.
Sulphur Capture in fluidized-bed pyrolysis with limestone,	New Brunswick Research and

dolomite and oil shale	Productivity Council
Coal/lime pyrolysis	Nova Scotia Research Foundation
Coal-Liquid Mixtures (CLM) Group	
Corrosion by carbogel	New Brunswick Research and Productivity Council
Development of an integrated R & D program for CLM including survey of hardware required	Nova Scotia Research Foundation, New Brunswick Productivity Council, Technical University of Nova Scotia
Management of round-robin on intercomparison of particle-size analysis and viscosity in CLM	Nova Scotia Research Foundation
Ceramics for coal utilization resistant to abrasion and thermal shock	Nova Scotia Research Foundation
Reactivity of limestone related to use of CLM in small fluid-bed reactors	Technical University of Nova Scotia
Flame tunnel burns of fuels from Chemistry Division of National Research Council (NRC)	CLM Technology Ltd.
Erosion resistance of coatings of plasma-sprayed alumina	Technical University of Nova Scotia
Testing NRC burner at Tuft's Cove	CLM Technology Ltd.

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Glossary

alluvial fan
: a generally fan- or partial cone-shaped deposit of sediments (mud, sand, gravel) formed by streams issuing from mountains onto a level plain

anastomosed (river)
: a branching, intercommunicating stream of lower sinuosity than a braided river

anthracite
: coal of high metamorphic rank, having a fixed carbon content of 92-98 percent

anticline
: a fold that is convex upward

ash content
: the inorganic residue remaining after the combustion of coal; expressed as percentage by weight

beneficiation
: a process by which the quality of the coal is improved

bituminous coal
: coal that contains greater than 14 percent volatile matter and has a calorific value exceeding 26.7 MJ/kg

(11,500 BTU/lb)

braided river
a river flowing in several dividing and reuniting channels; the cause of braiding being deposition of sediment, causing obstruction of the stream

braidplain
a broad plain of coalescing braided streams, often associated with distal alluvial fans

clastic
consisting of fragments of rock or organic matter transported from their place of origin

coal
a compact, stratified rock composed largely of chemically and physically altered plant remains mixed with a variable but subordinate amount of inorganic material; the type of coal depends upon the contributing plants, while the coal's rank depends upon the degree of metamorphism

coalification
the process by which vegetable matter is transformed into coal by physical and chemical changes after burial (diagenesis), and by metamorphism

coal measures
a succession of sedimentary rocks or strata in which interstratified beds of coal occur

compaction
a decrease in the volume of sediments, usually due to continued deposition above them, largely through water loss

competent
strata inherently strong enough to support their own weight plus the additional weight of overlying rocks

conglomerate
a cemented clastic rock containing variously rounded fragments of gravel or pebble size

cyclone
a washing device in which coal is separated from heavier impurities by centrifugal force (through spinning)

deltaic
referring to alluvial sediments usually deposited at the juncture of two bodies of water such as a river and lake, deltas are commonly triangular in plan and coarsen upward

diamond drilling
a form of drilling commonly implemented by geologists to retrieve rock samples from strata; utilizes a rotary drill bit impregnated with industrial diamonds to facilitate cutting through rock

diaper
a piercement fold, often comprising lower density rocks such as salt or gypsum

dip
the angle a bedding plane of rock makes with the horizontal (perpendicular to the strike of the bed)

distal
that position further away from the point of reference

dragline
: a large machine (usually track-mounted) that utilizes an earth-scraping bucket suspended by cables from a derrick, the bucket is dragged over and excavates a surface toward the machine often used in open-pit mining

ephemeral stream
: a stream that flows sporadically as a direct response to precipitation

evaporate
: a sediment deposited from aqueous solution as a result of evaporation

face
: refers generally to that section of the seam currently being mined or developed

facies
: a rock or group of rocks distinguished from other related rocks by appearance or composition

fault
: a fracture or zone of fracture along which displacement has occurred

fixed carbon
: that solid constituent of coal, other than inorganic ash, remaining after the volatile matter is driven off

flexure
: the line of maximum curvature or bending in a fold

floodplain
: that portion of a river valley built of sediments deposited by the river and occasionally covered by river floodwaters

fluidization
: a roasting process in which solid materials are kept in suspension by a rising current of air or other gas: an ideal condition for gas/solid reaction because each solid particle is in contact with a moving gas stream on all sides

fluvial
: pertaining to rivers

fluvio-lacustrine
: pertaining to a combination of river and lake influences

fold
: a bend in strata

framboid
: a microscopic spheroidal cluster of pyrite grains resembling a raspberry (*framboise* French)

glacial till
: nonsorted, nonstratified sediment deposited by a glacier

graben
: a block bounded by faults that has been downthrown relative to rocks on either side

lacustrine
: pertaining to lakes

lignite
an intermediate form of coal that has undergone a higher degree of coalification than peat but less than sub-bituminous coal (less than 19.3 MJ/kg or 8,300 BTU/lb)

liquefaction
the process of making or becoming liquid; conversion of a solid into a liquid by heat, or of a gas into a liquid by cold or pressure

lithological
pertaining to the physical character of a rock

maceral
a microscopically recognizable component of coal (analagous to mineral in inorganic rocks) that can be related to original organic matter, the three maceral groups are vitrinite (including telinite and collinite), exinite (including resinite, sporinite, cutinite and alginite) and inertinite (including micrinite, macrinite, fusinite, semifusinite and sclerotinite)

meandering river
a mature river that winds freely on a broad floodplain

megascopic
referring to observations made with the unaided eye

metallurgical
pertaining to the production of raw metallic materials, including processes such as smelting

mesh
one of the openings between wires of a sieve or screen

mudstone
an indurated (hardened, consolidation) clay rock that is not fissle (easily split along bedding planes)

overburden
(1) in economic geology, the barren rock material overlying a coal seam;
(2) the unconsolidated, loose mud, silt, sand and gravel overlying bedrock

paleoenvironment
ancient external surrounding conditions

panel
a large rectangular block or pillar of coal, usually to be mined

peat
a dark brown to black accumulation of plant material that has undergone partial decomposition and disintegration

petrography
the physical character of a rock observed megascopically or microscopically

progressive onlap
a relationship within a succession of strata in which each unit reaches a depositional margin or pinch-out, and is transgressed by the next overlying unit, each successive unit terminates farther from the point of reference

proximal

that portion closer to the point of reference

pyrolysis
chemical decomposition by heat in the absence of air, common synonym is "devolatization"

rank
the degree of coalification that a coal has undergone; the parameters commonly used are moisture content, calorific value, volatile matter, carbon, hydrogen, and vitrinite (a coal maceral group) reflectance

reserve
a volumetric measure of coal, prior to mining, after application of mining parameters

resource
the measure of coal in place, estimated with varying degrees of certainty (measured, indicated, inferred) by geological methods

sandstone
a cemented, clastic sedimentary rock predominantly composed of sand-size grains

seismic survey
a survey of the structure of rocks in the subsurface utilizing techniques such as explosive charges or vibrations to create sonic waves

shaft
a vertical tunnel access to a coal seam, used particulary when access is unavailable or impractical by slope, or when the coal lies at great depth

shale
a laminated sedimentary rock primarily composed of clay-size grins

siltstone
a very fine-grained clastic rock composed primarily of silt-size grains

slope
a sloping tunnel access to a coal seam; often developed totally within the seam

spherical agglomeration
a process by which spherical globules of coal-oil-water mixtures are produced, using ultrasonic and chemical methods

spore
a minute, often microscopic asexual reproductive part of plants

strata
sedimentary rock beds or layers

stratigraphy
a geological discipline involved with the study of the formation, composition, distribution and correlation of stratified rocks

strike
the trend of the intersection of a bedding plane or fault with the horizontal (perpendicular to dip)

subaerial

conditions that exist on the surface of the land in open air

sub-bituminous coal
coal having a calorific value of 19.3-26.7 MJ/kg (8,300-11,500 BTU/lb), intermediate in rank between lignite and bituminous coal

subsidence
gradual downward settling of the earth's surface with little horizontal movement, caused by a variety of natural geological processes

sulphur content
the percentage of coal weight made up of organic sulphur, sulphides and sulphates

syncline
a fold in rocks in which the strata dip inward from both sides toward the axis

synclinorium
a broad regional syncline containing minor folds

thermal coal
broadly referring to a major use of coal as a source of energy in boilers such as those of electrical power-generating stations

volatile matter
the constituents of coal driven off as gases and vapours during heating, carefully prescribed methods are used to calculate the percentage of volatile matter within a coal

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